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Dixit et al.

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(54) **DATA DIMENSION IMPACT ANALYSIS**

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G06F 16/248 (2019.01)
G06F 16/28 (2019.01)
G06F 16/335 (2019.01)

(52) **U.S. Cl.**
CPC ***G06F 16/248*** (2019.01); ***G06F 16/283*** (2019.01); *G06F 16/335* (2019.01)

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See application file for complete search history.

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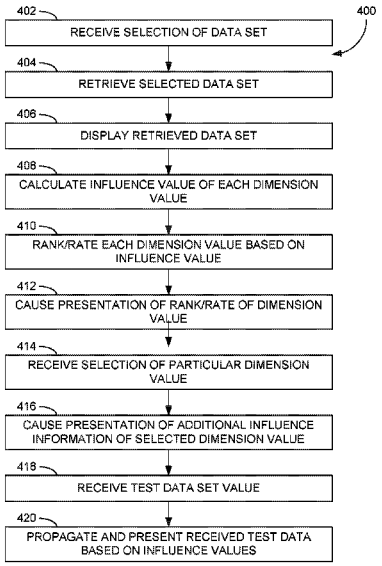
(57) **ABSTRACT**

Example embodiments of a system and method for analyzing and causing presentation of an impact or influence of a value of a dimension on a data set are described. In an example embodiment, a data set organized according to a first dimension is accessed from a data store. An influence value indicating an influence on the data set of at least one value of the first dimension is calculated. At least one of an influence rating and an influence ranking of the at least one value of the first dimension is determined based on the calculated influence value. The influence rating or ranking of the at least one value relative to other values of the first dimension is caused to be presented in conjunction with at least a portion of the data set organized according to the first dimension.

20 Claims, 8 Drawing Sheets



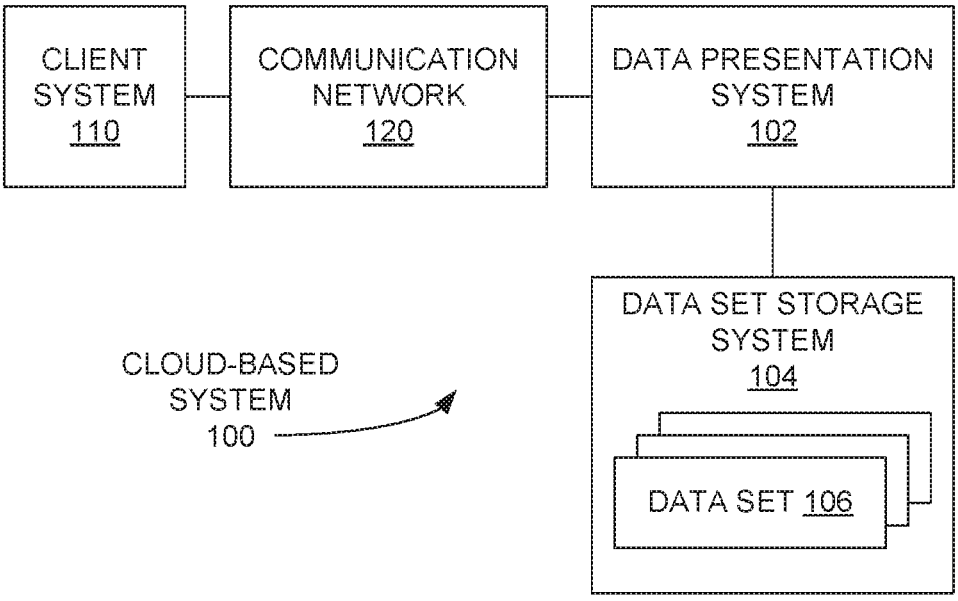

CLIENT SYSTEM 110
COMMUNICATION NETWORK 120
DATA PRESENTATION SYSTEM 102
DATA SET STORAGE SYSTEM 104
DATA SET 106
CLOUD-BASED SYSTEM 100

FIG. 1

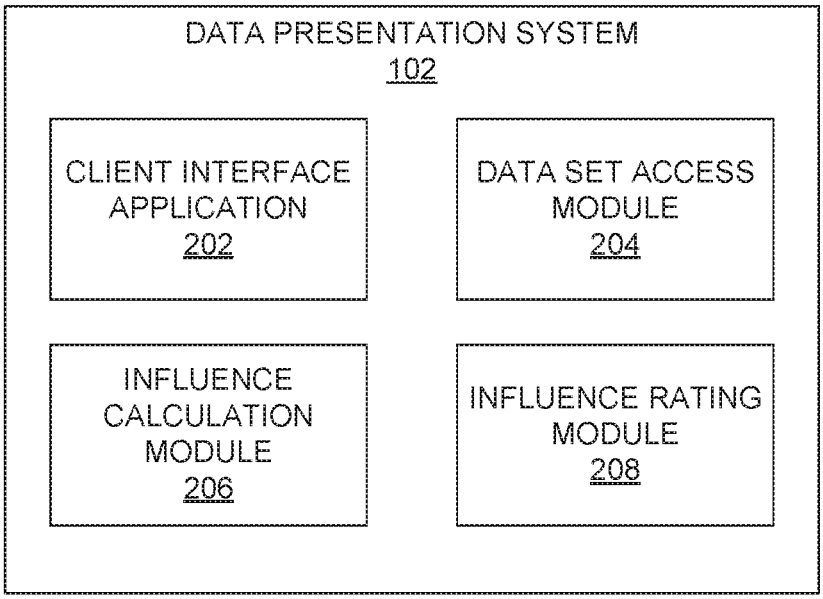
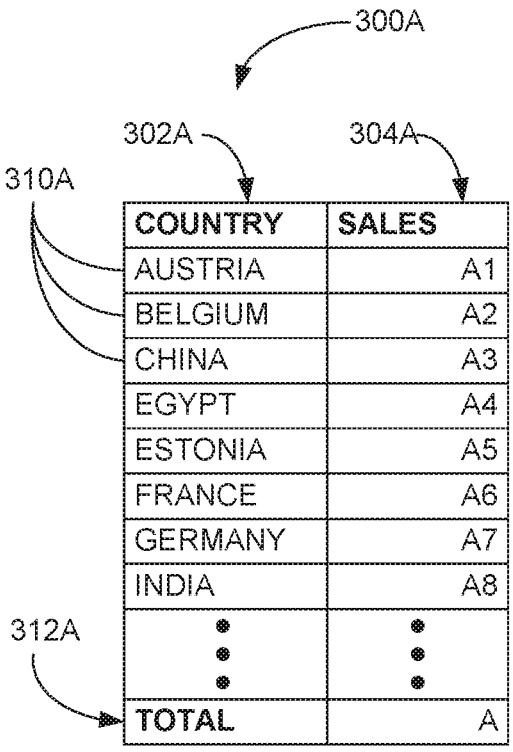
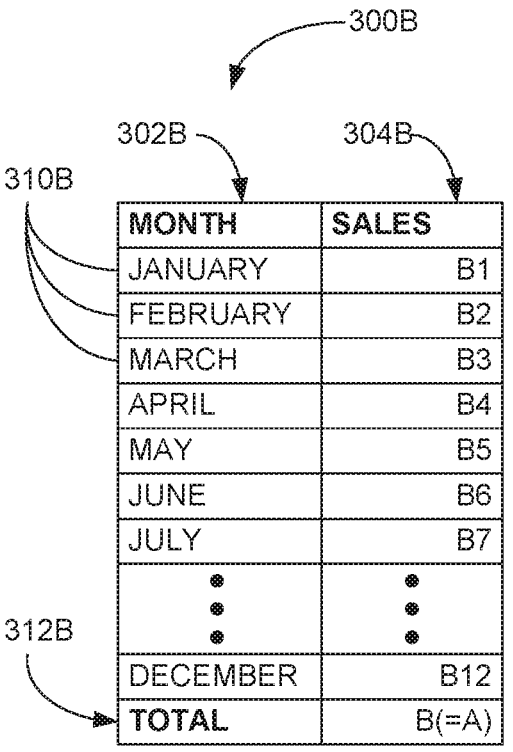

DATA PRESENTATION SYSTEM
102
CLIENT INTERFACE APPLICATION
202
DATA SET ACCESS MODULE
204
INFLUENCE CALCULATION MODULE
206
INFLUENCE RATING MODULE
208

FIG. 2



COUNTRY	SALES
AUSTRIA	A1
BELGIUM	A2
CHINA	A3
EGYPT	A4
ESTONIA	A5
FRANCE	A6
GERMANY	A7
INDIA	A8
⋮	⋮
TOTAL	A

FIG. 3A



MONTH	SALES
JANUARY	B1
FEBRUARY	B2
MARCH	B3
APRIL	B4
MAY	B5
JUNE	B6
JULY	B7
⋮	⋮
DECEMBER	B12
TOTAL	B(=A)

FIG. 3B

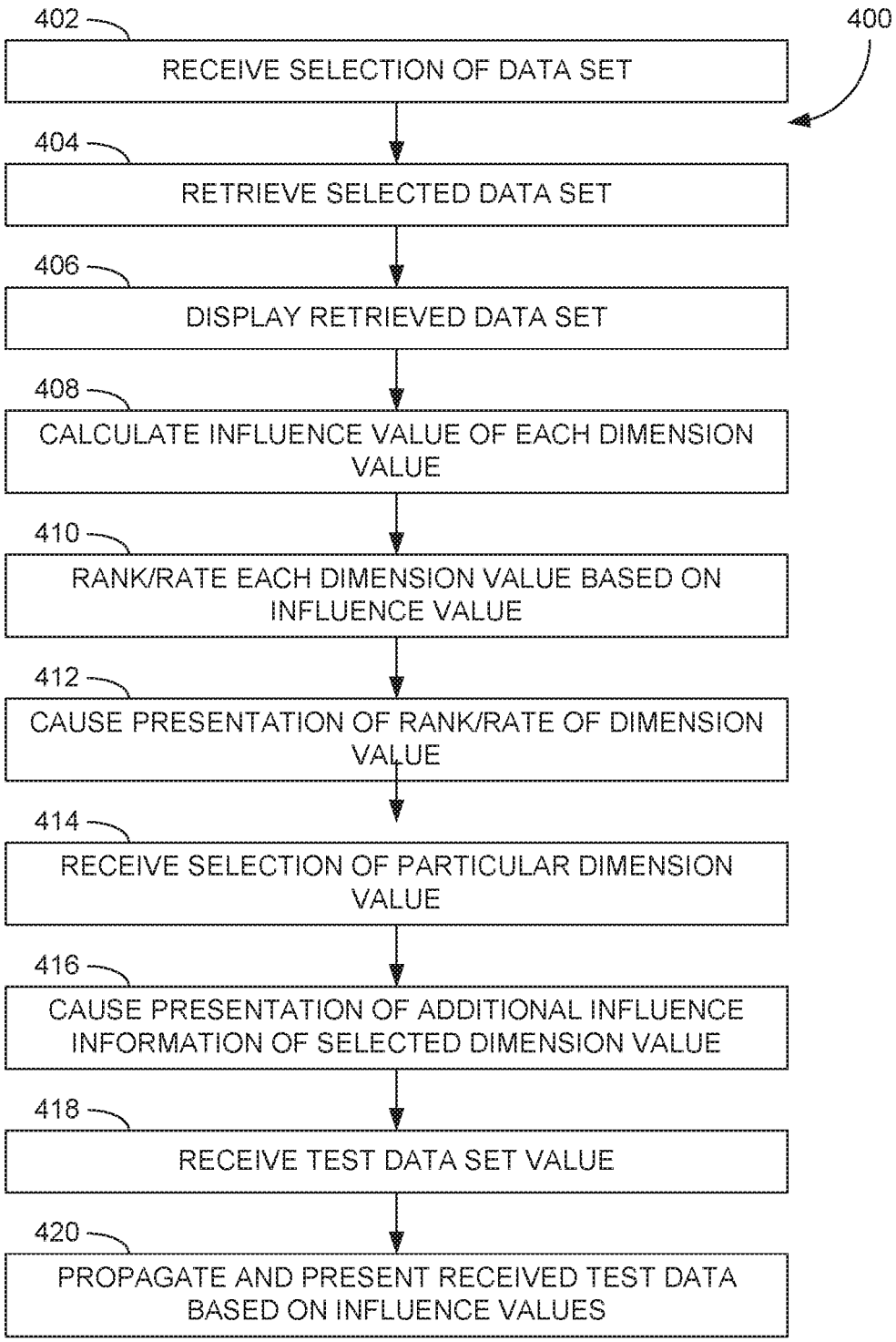

400
402
RECEIVE SELECTION OF DATA SET
404
RETRIEVE SELECTED DATA SET
406
DISPLAY RETRIEVED DATA SET
408
CALCULATE INFLUENCE VALUE OF EACH DIMENSION VALUE
410
RANK/RATE EACH DIMENSION VALUE BASED ON INFLUENCE VALUE
412
CAUSE PRESENTATION OF RANK/RATE OF DIMENSION VALUE
414
RECEIVE SELECTION OF PARTICULAR DIMENSION VALUE
416
CAUSE PRESENTATION OF ADDITIONAL INFLUENCE INFORMATION OF SELECTED DIMENSION VALUE
418
RECEIVE TEST DATA SET VALUE
420
PROPAGATE AND PRESENT RECEIVED TEST DATA BASED ON INFLUENCE VALUES

FIG. 4

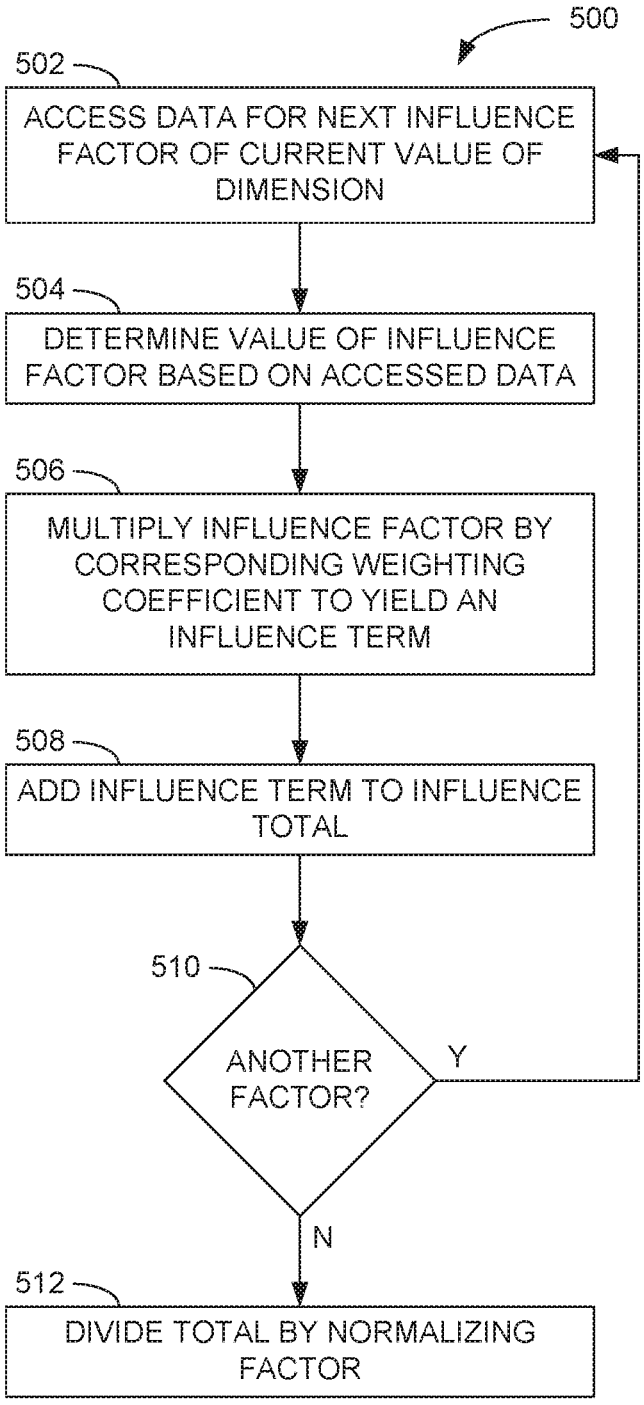

500
502
ACCESS DATA FOR NEXT INFLUENCE FACTOR OF CURRENT VALUE OF DIMENSION
504
DETERMINE VALUE OF INFLUENCE FACTOR BASED ON ACCESSED DATA
506
MULTIPLY INFLUENCE FACTOR BY CORRESPONDING WEIGHTING COEFFICIENT TO YIELD AN INFLUENCE TERM
508
ADD INFLUENCE TERM TO INFLUENCE TOTAL
510
ANOTHER FACTOR?
Y
N
512
DIVIDE TOTAL BY NORMALIZING FACTOR

FIG. 5

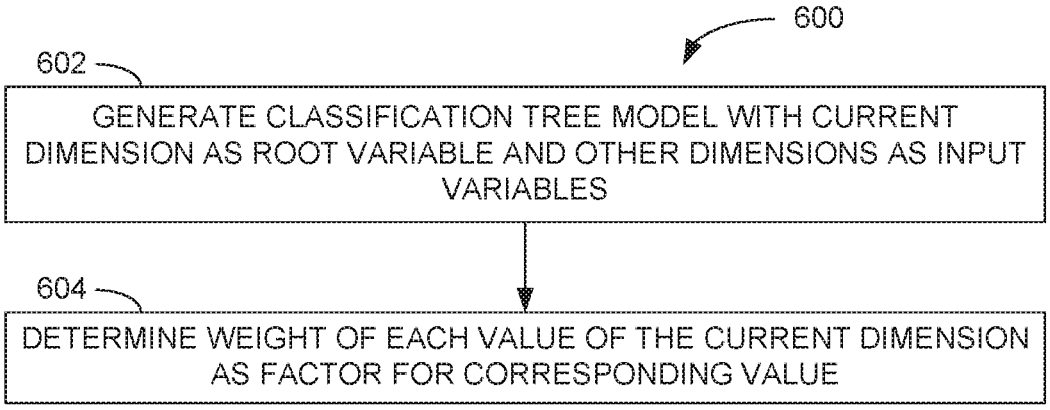
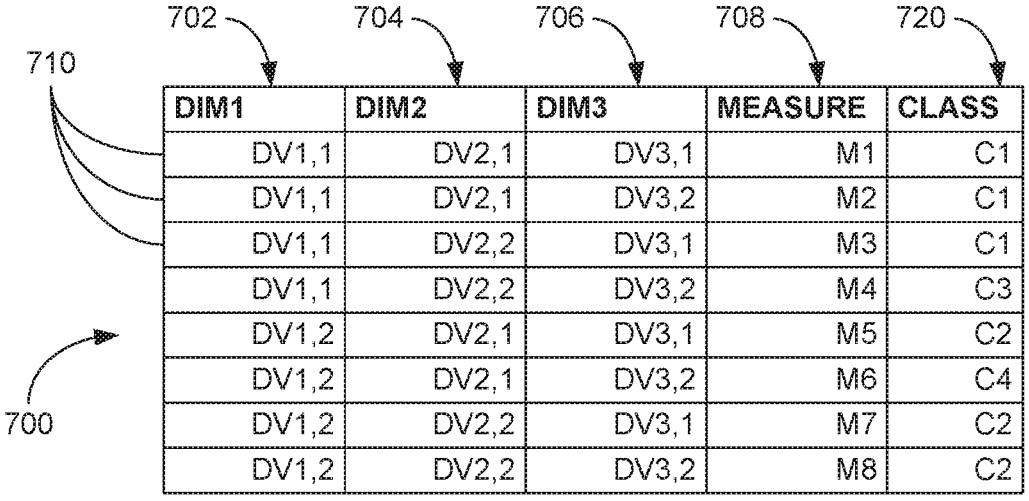


FIG. 6



DIM1	DIM2	DIM3	MEASURE	CLASS
DV1,1	DV2,1	DV3,1	M1	C1
DV1,1	DV2,1	DV3,2	M2	C1
DV1,1	DV2,2	DV3,1	M3	C1
DV1,1	DV2,2	DV3,2	M4	C3
DV1,2	DV2,1	DV3,1	M5	C2
DV1,2	DV2,1	DV3,2	M6	C4
DV1,2	DV2,2	DV3,1	M7	C2
DV1,2	DV2,2	DV3,2	M8	C2

FIG. 7

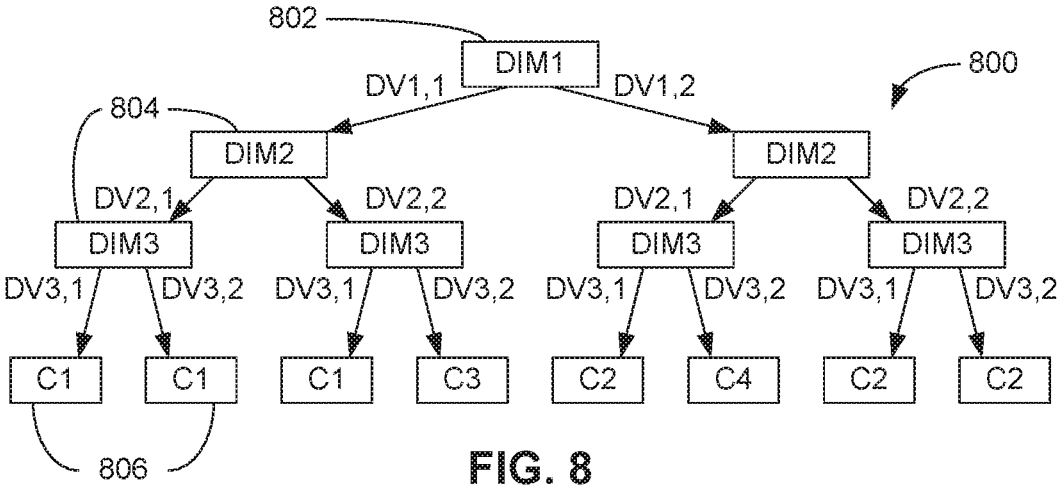


FIG. 8

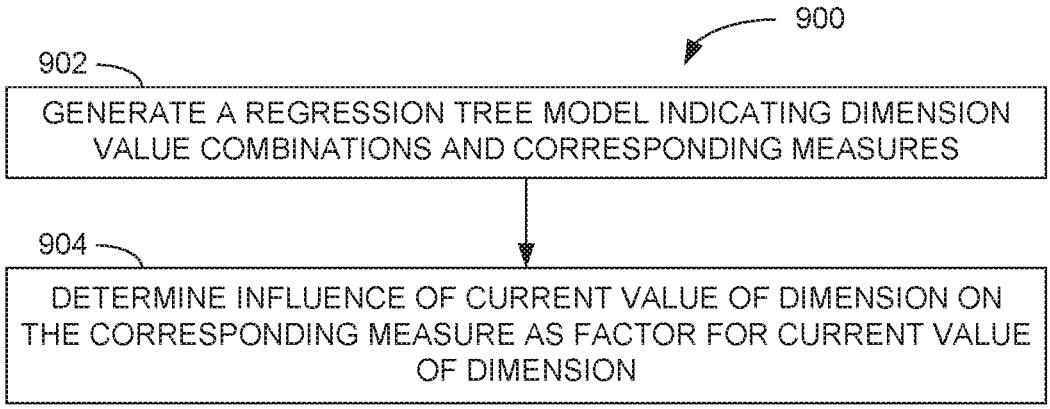

900
902
GENERATE A REGRESSION TREE MODEL INDICATING DIMENSION VALUE COMBINATIONS AND CORRESPONDING MEASURES
904
DETERMINE INFLUENCE OF CURRENT VALUE OF DIMENSION ON THE CORRESPONDING MEASURE AS FACTOR FOR CURRENT VALUE OF DIMENSION

FIG. 9

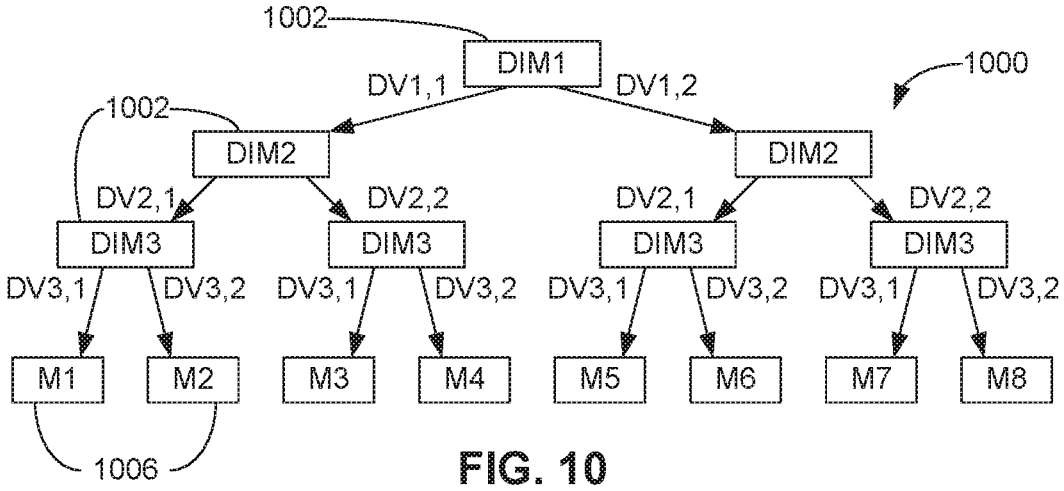

1002
DIM1
DV1,1
DV1,2
1000
1002
DIM2
DIM2
DV2,1
DV2,2
DV2,1
DV2,2
DIM3
DIM3
DIM3
DIM3
DV3,1
DV3,2
DV3,1
DV3,2
DV3,1
DV3,2
DV3,1
DV3,2
M1
M2
M3
M4
M5
M6
M7
M8
1006

FIG. 10

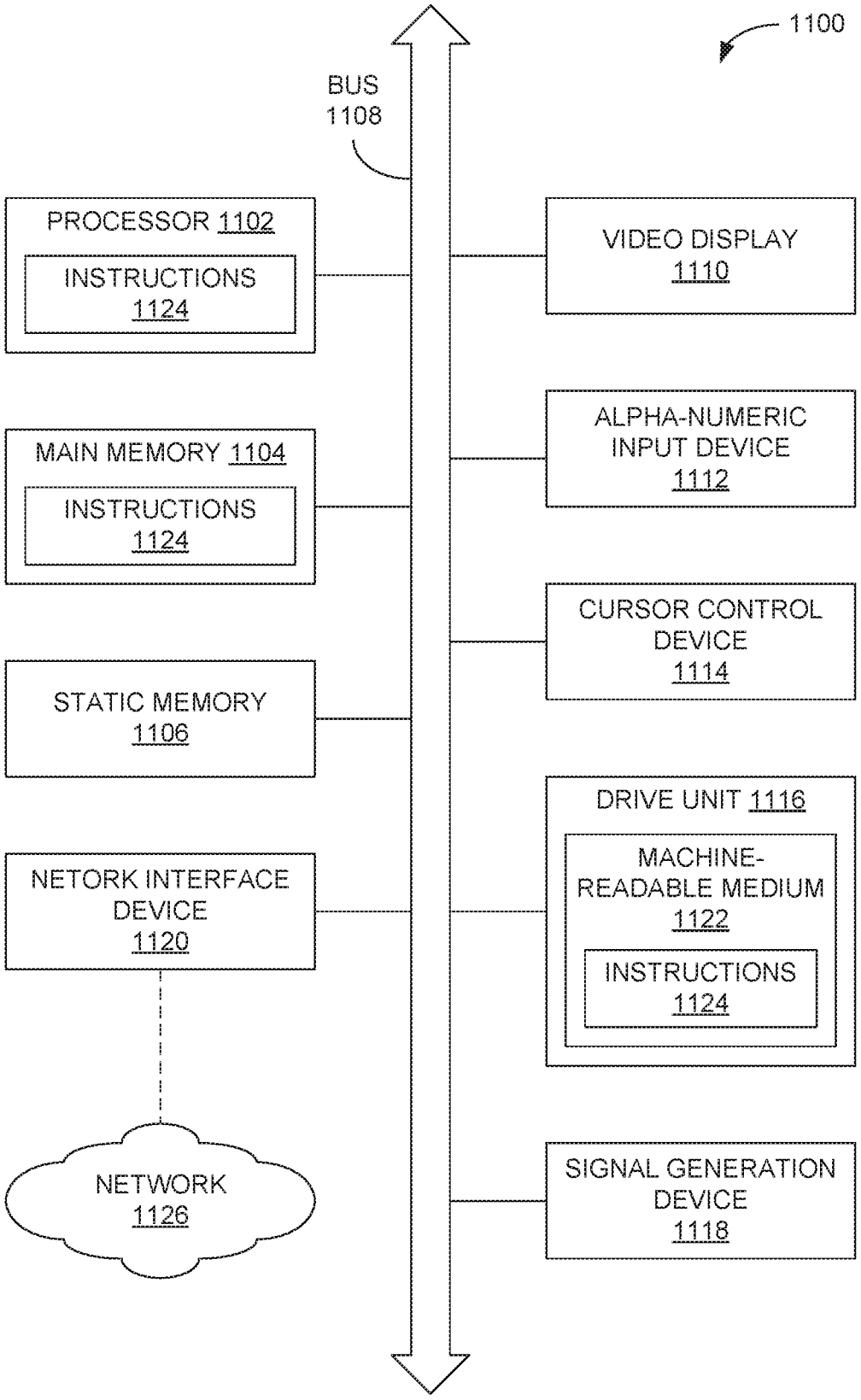

1100
BUS
1108
PROCESSOR 1102
INSTRUCTIONS
1124
MAIN MEMORY 1104
INSTRUCTIONS
1124
STATIC MEMORY
1106
NETORK INTERFACE
DEVICE
1120
NETWORK
1126
VIDEO DISPLAY
1110
ALPHA-NUMERIC
INPUT DEVICE
1112
CURSOR CONTROL
DEVICE
1114
DRIVE UNIT 1116
MACHINE-
READABLE MEDIUM
1122
INSTRUCTIONS
1124
SIGNAL GENERATION
DEVICE
1118

FIG. 11

DATA DIMENSION IMPACT ANALYSIS

FIELD

The present application relates generally to data processing and, more specifically in an example embodiment, to determining the impact or influence of data dimension values on a data set.

BACKGROUND

The analysis of large data sets (e.g., "big data," such as data stored in a data warehouse) has become an increasingly important function for many organizations and individuals. This data may represent various aspects of a particular subject matter area, such as product or service sales or revenue, employee compensation and benefits, component procurement, employment data, organization membership, television viewership, weather data, sports statistics, and so on. Analysis of such data often includes one or more of inspection, filtering, transformation, and modeling of data to facilitate the discovery of useful information for purposes of suggesting conclusions, supporting decision-making, and the like.

A continuing trend, particular in the area of business intelligence (BI), is the customization of data analysis by a consumer of that analysis (e.g., without the aid of an information technology expert). For example, a sales manager may want to determine which product of an array of products sold by his organization has the greatest impact on total revenue or profit. To that end, the sales manager may access a tool that allows the manager to vary how the data are processed and/or filtered, how the results are presented, and so on that may affect the overall data analysis. Due to the size or nature of the data set involved, however, the consumer of the data may not be able to determine which dimensions (e.g., data partitioning structures for categorizing facts or measures, such as according to people, product, place, time, etc.), individual data measures, or other portions of the data set have the greatest impact on the overall results indicated by the data set without either intimate knowledge of the data set itself or of the tool being used to analyze the data.

BRIEF DESCRIPTION OF DRAWINGS

The present disclosure is illustrated by way of example and not limitation in the figures of the accompanying drawings, in which like reference numbers indicate similar elements.

FIG. **1** is a block diagram of an example cloud-based system.

FIG. **2** is a block diagram of an example data presentation system of the example cloud-based system of FIG. **1**.

FIG. **3**A is a graphical representation of a data set organized according to a country dimension.

FIG. **3**B is a graphical representation of a data set organized according to a time (e.g., month) dimension.

FIG. **4** is a flow diagram of an example method of determining, and causing presentation of, an influence or impact of a value of a dimension of a data set.

FIG. **5** is a flow diagram of an example method of calculating an influence value for a dimension value.

FIG. **6** is a flow diagram of an example method of employing a classification tree model to determine a factor of an influence value for a dimension value.

FIG. **7** is a data set indicating various combinations of values of various dimensions with corresponding measures and classifications.

FIG. **8** is a classification tree model exemplifying the data set of FIG. **7**.

FIG. **9** is a flow diagram of an example method of employing a regression tree model to determine a factor of an influence value for a dimension value.

FIG. **10** is a regression tree model exemplifying the data set of FIG. **7**.

FIG. **11** is a block diagram of a computer processing system within which a set of instructions may be executed for causing a computer to perform any one or more of the methodologies discussed herein.

DETAILED DESCRIPTION

In the following description, for purposes of explanation, numerous specific details are set forth to provide an understanding of various example embodiments of the present subject matter. It will be evident, however, to those skilled in the art, that example embodiments of the present subject matter may be practiced without these specific details.

FIG. **1** is a block diagram of an example cloud-based system **100** in which a client system **110** accesses a data presentation system **102** by way of a communication network **120**, such as a wide area network (WAN) (e.g., the Internet), a wireless WAN (WWAN), a local area network (LAN), a wireless LAN (WLAN), a cellular data network (e.g., a third-generation (3G) or fourth-generation (4G) network), another communication connection, and/or combinations thereof. The client system **110**, the data presentation system **102**, or both may be responsible for executing at least some portion of an application in which a user interface (e.g., a graphical user interface (GUI)) is presented to a user of the client system **110** to facilitate presentation of one or more data sets **106** stored in a data set storage system **104** to the user. In one example, the data presentation system **102** executes a server-side application, while the client system **110** provides the user of the client system **110** an interface by which to interact with the server-side application, such as by way of a web browser application (e.g., by way of HyperText Transfer Protocol (HTTP)), a dedicated client application facilitating communication via an application programming interface (API) with the application executing on the data presentation system **102**, or other means. While a single client system **110** is depicted as being in communication with the data presentation system **102**, multiple such client systems **110** may be communicatively coupled with the data presentation system **102** via the communication network **120** in other embodiments.

In an example embodiment, the data set storage system **104** may be a data warehouse, database, or other type of data storage system in which one or more data sets **106** are stored for subsequent retrieval and/or analysis via the data presentation system **102**. In an example embodiment, the data set storage system **104** may include one or more data storage devices or systems for storing the data sets **106**, including, but not limited to, nonvolatile data storage devices (e.g., magnetic disk drives, optical disk drives, and/or flash memory), and possibly volatile data storage devices (e.g., dynamic random access memory (DRAM) devices, static random access memory (SRAM) devices, and so on). In an example embodiment, the data set storage system **104** may include one or more processors, controllers, or the like to receive storage, updating, and retrieval commands via the

data presentation system **102** and to access the data sets **106** in accordance with the received commands.

The data sets **106** stored in the data set storage system **104** may include business data, scientific data, sports data, and/or any other kind of data that may be organized along one or more dimensions. A dimension, as the term is used herein, is a data structure that is used to organize or categorize portions of a data set to enable data analysis, such as that found in business intelligence (BI) systems. Examples of dimensions include date, geography, people, products, and the like. For example, sales data may be may be organized according to year, so that sales of one year (e.g., 2014) may be compared against sales of the following year (2015). Moreover, a dimension may be hierarchical such that the data sets **106** may be organized in a more granular manner, such as by year, month, week, and day. Similar hierarchies may be used for geography (e.g., country, state, county, and so on), people (e.g., gender, age, and like), products (e.g., manufacturer, product line, individual product, etc.), and many other types of dimensions.

Additionally, each dimension includes a plurality of dimension values specifying particular members of the dimension. For example, a time dimension organized according to months of a particular year may have dimension values of "January," "February," and so on. Similarly, a geographic dimension organized by country may include dimension values of "United States," "India," "Japan," and so forth.

The data presentation system **102** may be configured to receive requests from the client system **110** to present one or more data sets **106**, or one or more portions thereof, via the client system **110** to a user. In response to those requests, the data presentation system **102** may retrieve the requested portions of the data sets **106** from the data set storage system **104** and transmit the requested data via the communication network **120** to the client system **110**. In an example embodiment, the data presentation system **102** may also present the requested data in a particular visual format (e.g., via a GUI) specified by the data presentation system **102**, the user (e.g., via the client system **110**), and/or another party.

In some example embodiments, the client system **110** may be a desktop computer, a laptop computer, a tablet computer, a smart phone, or any other communication device configured to generate requests for one or more data sets **106**, or portions thereof, as well as receive the requested data and present that data via a display device (e.g., display monitor, touch screen, or the like) to the user.

In example embodiments described in greater detail below, the data presentation system **102** may also determine the impact or influence of one or more values of one or more dimensions of the data set **106** relative to other dimension values of the data set **106**, and cause the presentation of a rating or ranking of that influence to the user via the client device **110**. For example, an expert in education may want to analyze a data set **106** directed to the literacy rate of different states in the United States. In analyzing the data, the expert, as a user or consumer of the data set **106**, may want to determine how much one or more of fifty individual states of the United States contributes to the overall literacy rate in the U.S., as well as the contribution of each state relative to the other states to that rate, so that educational efforts may be concentrated in particular states to increase the overall rate.

In another example, an executive of a retail chain including hundreds of retail outlets may want to determine how each of a plurality of factors influences purchasing decisions at each of the outlets, thereby impacting or influencing the overall revenue of the retail chain. By determining which factors have the most impact, the executive may be able to focus the efforts of the retail chain to improving the overall revenue of the chain. In yet another example, an analysis of the impact or contribution of each product sold by the outlets to the overall revenue of the retail chain may allow the executive to focus marketing efforts on those products that affect the overall revenue the most.

To address each of these examples, as well as many others, the data presentation system **102**, when called upon by a user to present one or more data sets **106** (e.g., by way of opening a workspace or document configured to present a data set **106** of the data set storage system **104**), may automatically determine an influence or impact of one or more dimension values of the data set **106** relative to other dimension values of the data set **106**, such as by way of generating an impact or influence rating and/or ranking for each of the dimension values. In some example embodiments, the data presentation system **102** may allow the user to select a particular dimension value (e.g., a particular month, or a particular store) and present detailed information regarding the influence of that particular dimension value to view the effect of that modification on the data set. In other example embodiments, the data presentation system **102** may allow the user to modify one or more data set **106** values to visualize the resulting effect on other values of the data set **106** based on the determined or calculated influence of the various dimension values. Other aspects regarding various example embodiments of the data presentation system **102** are discussed in greater detail below.

FIG. **2** is a block diagram of an example embodiment of the data presentation system **102** of the cloud-based system **100** of FIG. **1**. Shown within the data presentation system **102** are several components or modules, including a client interface application **202**, a data set access module **204**, an influence calculation module **206**, and an influence rating module **208**. Other components or modules not explicitly discussed herein may be included in the data presentation system **102** in other embodiments. In other example embodiments, one or more of the modules **202-208** may be omitted, or may be combined with other modules **202-208**. In an example embodiment, one or more of the modules **202-208** may be hardware circuitry, one or more hardware processors (e.g., a central processing unit (CPU), a graphical processing using (GPU), and/or the like) executing instructions stored in a memory, or some combination thereof. Moreover, while the example embodiments herein place the modules **202-208** within the data presentation system **102**, other example embodiments may locate one or more of the modules **202-208** or associated functionality in the client system **110**, possibly along with the data set storage system **104**.

In an example embodiment, the client interface application **202** may be configured to present one or more data sets **106**, or portions thereof, for viewing by a user via the client device **110**. In an example embodiment, the client interface application **202** may be a business intelligence (BI) program that presents data sets **106** (e.g., in relation to one or more dimensions) in one or more forms (e.g., tables, pie charts, bar graphs, etc.) for viewing by a user. An example of such a program may be Viz™ by SAP® SE of Walldorf, Germany, which presents data sets **106** in various formats, such as individual data "visualizations," or in data "stories" that may include multiple visualizations. However, many other types of client interface applications **202** may be employed in other example embodiments.

To provide the data from one or more data sets **106**, the data presentation system **102** may employ a data set access

module **204** configured to access the one or more data sets **106** stored in the data set storage system **104**. In an example embodiment, the data set access module **204** may be a database access module, a data warehouse access module, or another type of access module configured to provide commands corresponding to the type of data set storage system **104** being employed in the cloud-based system **100**.

In example embodiments described herein, the client interface application **202** may also be configured to provide an indication of an influence or impact rating or ranking of one or more dimension values on data values or measures of interest to the user. To that end, the data presentation system **102** may include an influence calculation module **206** configured to generate a numeric value indicating a level of impact or influence over a particular type of data of the data set **106**. In an example embodiment, the influence calculation module **206** may generate an influence value for each dimension value (e.g., January, February, etc.) of a dimension (e.g., month) of the portion of the data set **106** to be presented to the user.

In addition, the data presentation system **102** may include an influence rating module **208** configured to assign an influence rating and/or ranking to each of one or more dimension values of the same or different dimensions based on its corresponding influence value. In an example embodiment, an influence ranking may include, for example, an ordinal number ranking the influence of the corresponding dimension value relative to the influence of other dimension values based on their corresponding influence values. In other example embodiment, an influence rating may include, for example, a rating from 1 to some maximum number (e.g., 5, 10, etc.) that exemplifies a relative influence of each dimension value compared to other dimension values.

FIGS. **3**A and **3**B are graphical representations of data sets **300** organized according to a particular dimension **302**. More specifically, FIG. **3**A provides a data set **300**A indicating an amount of sales **304**A for each of a number of countries **310**A of a geographic dimension **302**A, along with a sales total **312**A. FIG. **3**B is a graphical representation of a data set **302**B indicating an amount of sales **304**B for each month **310**B of a particular year dimension **302**B, as well as a sales total **312**B for that year. In an example embodiment, the information presented in the data sets **300**A, **300**B may be from the same data set **106**, which may result in the sales total **312**A equaling the sales total **312**B. Consequently, the data presentation system **102** may rate and/or rank one or more dimension values **310**A, **310**B of either or both of the displayed dimensions **302**A, **302**B.

FIG. **4** is a flow diagram of an example method **400** for determining, and causing presentation of, an influence or impact of a value **310** of a dimension **302** of a data set **106**. While the method **400** is described in various example embodiments below as being performed by the data presentation system **102**, other modules or systems, such as the client device **110** of FIG. **1**, may perform the method **400**, or some portion thereof, in other example embodiments.

In the method **400**, the data presentation system **102** (e.g., via the client interface application **202**) may receive a selection of a data set **106** (operation **402**), or a portion thereof, or multiple data sets **106**, from the client device **110** via the communication network **120**. In response to the selection, the data presentation system **102** may retrieve the selected data set **106** from the data set storage system **104** (e.g., via the data set access module **204**) (operation **404**). The client interface application **202** may then cause the retrieved data set **106** to be presented to the user (operation **406**), such as by transmitting the data set **106** in a numerical, tabular, graphical, or other format via the communication network **120** to the client device **110**, at which the data set **106** may be presented to the user via a display device.

In example embodiments, the data presentation system **102** (e.g., via the influence calculation module **206**) may calculate an influence value for each dimension value **310** of one or more dimensions **302** of the data set **106** (operation **408**). Further, in some example embodiments, the data presentation system **102** (e.g., via the influence rating module **208**) may generate a ranking and/or rating of the influence of one or more dimension values **310** of the one or more dimensions **302** (operation **410**) and cause presentation of the ranking and/or rating information (operation **412**) (e.g., in conjunction with the presentation of the retrieved data set **106**). Details regarding calculation of the influence values in some example embodiments is provided below in conjunction with FIGS. **5-10**.

In an example embodiment, the data presentation system **102** (e.g., via the client interface application **202**) may also receive a selection of a particular dimension value **310** (operation **414**) from the client device **110**. In response, the data presentation system **102** may cause presentation of additional influence information (e.g., the calculated influence value and one or more factors employed to calculate the influence value) for the selected dimension value **310** (operation **416**), as calculated via the influence calculation module **206**.

In another example embodiment, the data presentation system **102** (e.g., via the client interface application **202**) may receive a test or proposed value for one or more values or measures of the data set **106** (operation **418**). In response, the data presentation system **102** (e.g., via the influence calculation module **206**) may propagate the test value through other values or measures of the data set **106** based on the calculated influence values of the dimension values **310** of the one or more dimensions **302** (operation **420**).

While the particular operations **402-420** of the method **400** of FIG. **4**, as well as the operations of other methods described below, are depicted as being performed in a particular order, other orders of operation, including simultaneous or concurrent execution of two or more of the operations **402-420**, are also possible in some embodiments.

FIG. **5** is a flow diagram of an example method **500** of calculating an influence value for a dimension value **310** of a dimension **302**. In an example embodiment, the influence value of a dimension value **310** on the data set **106** may be based on any number of factors, such as how the dimension value **310** affects the numerical values or measures of the data set **106**, how the dimension value **310** affects the presentation of the data set **106** to the user (e.g., by use of the dimension value **310** as a filter or formatting factor in the presentation of the data set **106**), how the dimension value **310** is used in selecting other data to be merged or appended to the data set **106**, and so on. In some example embodiments, a numerical value may represent each such factor. Further, one or more of these factors may be weighted by way of a corresponding coefficient before being summed to determine an overall influence value of the particular dimension value **310** on the data set **106**.

In the method **500**, as may be executed by the influence calculation module **206**, data may be accessed that is pertinent to an influence factor in calculating the influence value for one or more dimension values **310** (operation **502**). A value for the influence factor may then be determined based on the accessed data (operation **504**). The determined value may then be multiplied by corresponding weighting coefficient (operation **506**) to yield an influence term, and

the influence term may be added to an influence total (operation **508**). If more influence factors remain to be processed (operation **510**), operations **502-508** are executed for each such influence factor. In some example embodiments, the resulting influence total, after all influence factors are included, may be divided by a normalizing factor (operation **512**) or other divisor to produce the influence value for the corresponding dimension value **310**. This process may be repeated for each dimension value **310** of one or more dimensions **302** of the data set **106**.

In an example embodiment in which eight factors are considered in determining the impact or influence of a particular dimension value **310**, the overall calculated impact or influence value for that dimension value **310** may be as follows:

$$F(x)=(f(n1*k1)+f(n2*k2)+f(n3*k3)+f(n4*k4)+f(n5*k5)+f(n6*k6)+f(n7*k7)+f(n8*k8))/d$$

In this example, F(x) is the overall calculated influence value, kx is a calculated or determined value for one of the influence factors involved in determining the influence value, nx is the associated weighting coefficient for that particular factor to yield an influence term, f(nx*kx) may be a scaling function, normalizing function, or other type of function applied to an influence term, and d may be a normalizing factor or other type of factor by which to divide the sum of weighted terms to yield the overall influence value F(x). In one example embodiment, the normalizing factor d may be an integer (e.g., 5), but many other values for the normalizing factor d are also possible. While this particular influence function employs eight factors, other influence functions may employ any number of factors (e.g., from one to greater than eight).

FIG. **6** is a flow diagram of an example method **600** of employing a classification tree model to determine a factor of an influence value for a dimension value **310**. In the method **600**, the influence calculation module **206** may generate a classification tree model (operation **602**) associated with the dimension value **310**. In an example embodiment, the classification tree model may employ the dimension **302** of the current dimension value **310** as a root node or variable, and one or more other dimensions **302** as other input nodes or variables, with the classification tree including a number of classifications for the various measures of the data set **106** as leaf nodes.

Based on a weight associated with each leaf node of the classification tree model, a weight for one or more dimension values **310** of the dimension **302** serving as the root node of the classification tree model may be determined (operation **604**), with the determined weight being used as a factor of the influence value described above with respect to FIG. **5**. In an example embodiment, the weight of each leaf node is represented by the number of measures of the data set **106** falling within the classification represented by the corresponding leaf node.

FIG. **7** is a data set **700** indicating various combinations of dimension values **710** of various dimensions **702**, **704**, **706** with corresponding measures **708** and classifications **720**. In this particular simplified example, each of dimension **702** (DIM1), dimension **704** (DIM2), and dimension **706** (DIM3) have two possible dimension values **710** each (e.g., DV1,1 and DV1,2 for DIM1; DV2,1 and DV2,2 for DIM2; and DV3,1 and DV3,2 for DIM3). For each possible combination of dimension values **710**, the data set **106** provides a measure **708** (e.g., an amount of sales) for the corresponding dimension values **710** (e.g., a particular geographic area for DIM1, a particular time frame for DIM2, and a particular product for DIM3). In addition, each of the measures **708** may be classified in a particular classification **720** C1-C4. In an example embodiment, each classification **720** may represent a range of values for the measure **708** (e.g., "high," "high average," "low average," and "low"). In example embodiments, these classifications may be determined by the user, the data presentation system **102**, or another system or person.

Based on the data set **700**, a corresponding classification tree model **800** may be generated, as illustrated in FIG. **8**. In the classification tree model **800**, the first dimension DIM1 is employed as the root node **802**, the second dimension DIM2 and the third dimension DIM3 are other input nodes **804**, and the leaf nodes **806** represent the classifications **720** C1-C4. As shown in FIG. **8**, a value for DIM1 of DV1,1; a value for DIM2 of DV2,1; and a value for DIM3 of DV2 results in a classification of C1. In an example embodiment, the classification tree model **800** of FIG. **8** may be simplified in cases where a value of a particular dimension **702**, **704**, **706** does not affect the resulting classification **720** of the associated data. For example, if DIM1 is DV1,1 and DIM2 is DV2,1, either value of DIM3 (DV3,1 or DV3,2) results in classification C1. Thus, the associated portion of the classification tree model **800** may be removed, with a value of DV2, 1 for DIM2 indicating a resulting classification of C2 with a corresponding weight of two.

Using either the data set **700** or the associated classification tree model **800**, the influence calculation module **206** may determine a weight for each dimension value DV1,1 and DV1,2 of DIM1 associated with each classification **720**. In this example embodiment, the weight of the first value DV1,1 of DIM1 for classification C1 is three, while the weight of the second value DV2,2, of DIM1 for classification C1 is zero. Other weights for the various dimension values **710** relative to each classification **720** may be derived in a similar manner. The weights for each dimension value **710** may be combined (e.g., summed, averaged, etc.) to yield an overall weight for an influence factor (e.g., k1) for that dimension value **710**.

In an example embodiment, the corresponding coefficient (e.g., n1) may be 10000, although other coefficients n1 are also possible.

FIG. **9** is a flow diagram of an example method **900** of employing a regression tree model to determine another factor of an influence value for a dimension value **310** of a dimension **302**. In the method **900**, a regression tree model indicating combinations of dimension values **310** and corresponding measures of the data set **106** is generated (operation **902**). Based on the regression tree model, an influence factor for each dimension value **310** indicating the influence of the dimension value **310** on the corresponding measure of the data set **106** may be determined (operation **904**).

FIG. **10** is a regression tree model **1000** exemplifying the data set **700** of FIG. **7**. In this example embodiment, the dimension **702** being analyzed (e.g., DIM1) may again serve as a root node **1002** and the other dimensions **704**, **706** (e.g., DIM2 and DIM3) may serve as other input nodes **1004**, although other examples are also possible. In this example embodiment, the leaf nodes **1006** represent particular measures **708** instead of classifications **720**. Similar to the case described above with the classification tree model **800**, the regression tree model **1000** may be simplified relative to that shown in FIG. **10**, as some of the resulting measures **708** (e.g., M1 and M2) may be the same, or nearly so. Based on the resulting regression tree model **1000**, the effect of each dimension value **710** combination (e.g., DV1,1 of DIM1; DV2,1 on DIM2; and DV3,1 of DIM3) on its corresponding

measure **708** may be taken into account to determine the weight of a particular dimension value **710** on each measure **708**. The weights for each dimension value **710** may then be combined (e.g., summed, averaged, or the like) to yield an influence factor (e.g., k2) for the overall influence value to be calculated.

In an example embodiment, the corresponding coefficient (e.g., n2) may be 9000, although other coefficients n2 are also possible.

In an example embodiment, another factor (e.g., k3) may be the number of conditional visual formatting operations (e.g., underlining, italicizing, bolding, different font color, etc.) for presenting values of the data set **106** to the user, such as those employed in a worksheet or document presented by the data presentation system **102** that are based on the particular dimension value **310** that is being rated and/or ranked. In one example embodiment, the corresponding coefficient n3 may be 5000, although other coefficients n3 are also possible.

In another example embodiment, another factor (e.g., k4) may be the number of data filters for calculating and/or presenting one or more aspects of the data set **106** to the user that are based on the particular dimension value **310** that is being rated and/or ranked. In one example embodiment, the corresponding coefficient n4 may be 3000, although other coefficients n4 are also possible.

Also in an example embodiment, another factor (e.g., k5) may be the number of times the particular dimension value **310** is presented to the user (e.g., in a data "visualization" (e.g., a particular data format in which data of the data set **106** is to be presented, such as a table, bar graph, pie chart, or the like) or a data "story" (e.g., a user interface in which multiple data visualizations may be displayed on a single page or screen)). In one example embodiment, the corresponding coefficient n5 may be 2000, although other coefficients n5 are also possible.

In the example embodiment, another factor (e.g., k6) may be the number of times a calculation or presentation filter is employed on the dimension value **310** in a data set **106** presented to the user. In one example embodiment, the corresponding coefficient n6 may be 1000, although other coefficients n6 are also possible.

Further in an example embodiment, another factor (e.g., k7) may be the number of times that the particular dimension value **310** is employed to merge or append data sets **106**, such as from multiple database tables of the data set storage system **104**. In one example embodiment, the corresponding coefficient n7 may be 100, although other coefficients n7 are also possible.

In another example embodiment, another factor (e.g., k8) may be the number of different dimension **302** hierarchies within which the particular dimension value **310** is represented. For example, a geographic dimension **302** may include the particular hierarchical levels of nation, state, county, and city/town. Other types of well-known dimension hierarchies (e.g., based on time, location, product, and so on), as well as more customized (e.g., user-defined) dimension hierarchies, in which the particular dimension value **310** may be represented may also be counted. In one example embodiment, the corresponding coefficient n8 may be 10, although other coefficients n8 are also possible.

Consequently, application of the various aspects of the example embodiments discussed herein may provide a method of generating a quantifiable value representing the impact or influence of one or more dimensions **302** or included dimension values **310** of a data set **106**, and of using that value to automatically provide an indication to the user of the relative influence or importance of those dimension values **310** within the data set **106** to the user, thus enhancing the analytical value of the data set **106**.

In an example embodiment, a system comprises one or more hardware processors and a memory storing instructions that, when executed by at least one of the one or more hardware processors, cause the system to perform operations comprising accessing, from a data store, a data set organized according to a first dimension; calculating an influence value indicating an influence, on the data set, of at least one value of the first dimension; determining at least one of an influence rating and an influence ranking of the at least one value of the first dimension based on the calculated influence value; and causing, via a display device, presentation of the at least one of an influence rating and an influence ranking of the at least one value of the first dimension relative to other values of the first dimension in conjunction with a presentation of at least a portion of the data set organized according to the first dimension.

In another example embodiment, including all previous example embodiments, the calculating of the influence value comprises determining each of a plurality of factors indicating a type of influence, on the data set, of the at least one value of the first dimension; multiplying, for each of the plurality of factors, the factor by a corresponding coefficient to yield a corresponding influence term; and summing the corresponding influence terms.

In another example embodiment, including all previous example embodiments, the calculating of the influence value further comprises dividing the summed corresponding influence terms to produce the influence value.

In another example embodiment, including all previous example embodiments, the calculating of the influence value comprises generating, for the at least one value of the first dimension, at least one classification tree model; and determining, for the at least one classification tree model, a weight of the at least one value of the first dimension, the influence value being based on the weight.

In another example embodiment, including all previous example embodiments, a target variable of the at least one classification tree model comprises a classification of a group of measures of the data set.

In another example embodiment, including all previous example embodiments, a root node of the at least one classification tree model comprises the first dimension.

In another example embodiment, including all previous example embodiments, the data set is organized according to a plurality of dimensions comprising the first dimension, an input variable of the at least one classification tree comprising a second dimension of the plurality of dimensions.

In another example embodiment, including all previous example embodiments, the calculating of the influence value comprises generating a regression tree model indicating an influence of the at least one value of the first dimension on each of a plurality of measures of the data set, the influence value being based on the regression tree model.

In another example embodiment, including all previous example embodiments, the calculating of the influence value comprises determining a number of times at least one conditional visual format is applied to the at least one value of the first dimension, the influence value being based on the number of times the at least one conditional visual format is applied to the at least one value of the first dimension.

In another example embodiment, including all previous example embodiments, the calculating of the influence value comprises determining a number of presentation filters being

based on the at least one value of the first dimension, the influence value being based on the number of presentation filters.

In another example embodiment, including all previous example embodiments, the calculating of the influence value comprises determining a number of times the at least one value of the first dimension is employed in one or more data set visualizations to be presented to a user, the influence value being based on the number of times the at least one value of the first dimension is employed in the one or more data set visualizations.

In another example embodiment, including all previous example embodiments, the calculating of the influence value comprises determining a number of times the at least one value of the first dimension is employed in one or more user interface pages to be presented to a user, the influence value being based on the number of times the at least one value of the first dimension is employed in the one or more user interface pages.

In another example embodiment, including all previous example embodiments, the calculating of the influence value comprises determining a number of times the at least one value of the first dimension is employed to merge a plurality of data tables of the data set, the influence value being based on the number of times the at least one value of the first dimension is employed to merge the plurality of data tables of the data set.

In another example embodiment, including all previous example embodiments, the calculating of the influence value comprises determining a number of times the at least one value of the first dimension is employed in one or more geographic dimension hierarchies of the data set, the influence value being based on the number of times the at least one value of the first dimension is employed in the one or more geographic dimension hierarchies of the data set.

In another example embodiment, including all previous example embodiments, the calculating of the influence value comprises determining a number of times the at least one value of the first dimension is employed in one or more user-defined dimension hierarchies of the data set, the influence value being based on the number of times the at least one value of the first dimension is employed in the one or more user-defined dimension hierarchies of the data set.

In another example embodiment, including all previous example embodiments, the operations further comprise receiving a user selection of one of the at least one value of the first dimension; and causing, via the display device, presentation of an indication of at least one factor of a plurality of numerical factors upon which the influence rating of the selected one of the at least one value of the first dimension is based.

In another example embodiment, including all previous example embodiments, the first dimension comprises a geographic dimension.

In another example embodiment, including all previous example embodiments, the system further comprises a communication network interface configured to communicate via a communication network with a client device, the client device comprising the display device.

In an example embodiment, a method comprises accessing, from a data store, a data set organized according to a first dimension; calculating, using at least one hardware processor of a machine, an influence value indicating an influence, on the data set, of at least one value of the first dimension; determining at least one of an influence rating and an influence ranking of the at least one value of the first dimension based on the calculated influence value; and causing, via a display device, presentation of the at least one of an influence rating and an influence ranking of the at least one value of the first dimension relative to other values of the first dimension in conjunction with a presentation of at least a portion of the data set organized according to the first dimension.

In an example embodiment, a non-transitory computer-readable storage medium storing instructions that, when executed by one or more processors of a machine, cause the machine to perform operations comprising accessing, from a data store, a data set organized according to a first dimension; calculating an influence value indicating an influence, on the data set, of at least one value of the first dimension; determining at least one of an influence rating and an influence ranking of the at least one value of the first dimension based on the calculated influence value; and causing, via a display device, presentation of the at least one of an influence rating and an influence ranking of the at least one value of the first dimension relative to other values of the first dimension in conjunction with a presentation of at least a portion of the data set organized according to the first dimension.

FIG. **11** is a block diagram of a computer processing system **1100** within which a set of instructions **1124** may be executed for causing a computer to perform any one or more of the methodologies discussed herein, such as those discussed in conjunction with FIGS. **4-10**, as well as other methodologies discussed herein. In some embodiments, the computer operates as a standalone device or may be connected (e.g., networked) to other computers. In a networked deployment, the computer may operate in the capacity of a server or a client computer in a server-client network environment, or as a peer computer in a peer-to-peer (or distributed) network environment. Moreover, the computer processing system **1100** may serve in example embodiments as, for example, the data presentation system **102** of FIGS. **1** and **2**, as well as any component or module **202-208** described therewith.

In addition to being sold or licensed via traditional channels, embodiments may also be deployed, for example, by software-as-a-service (SaaS) providers, application service providers (ASPs), or by utility computing providers. The computer may be a server computer, a personal computer (PC), a tablet PC, a personal digital assistant (PDA), a cellular telephone, or any processing device capable of executing a set of instructions (sequential or otherwise) that specify actions to be taken by that device. Further, while only a single computer is illustrated, the term "computer" shall also be taken to include any collection of computers that, individually or jointly, execute a set (or multiple sets) of instructions to perform any one or more of the methodologies discussed herein.

The example computer processing system **1100** includes a processor **1102** (e.g., a central processing unit (CPU), a graphics processing unit (GPU), or both), a main memory **1104**, and a static memory **1106**, which communicate with each other via a bus **1108**. The computer processing system **1100** may further include a video display **1110** (e.g., a plasma display, a liquid crystal display (LCD), or a cathode ray tube (CRT)). The computer processing system **1100** also includes an alphanumeric input device **1112** (e.g., a keyboard), a user interface (UI) cursor control device **1114** (e.g., a mouse and/or touch screen), a drive unit **1116**, a signal generation device **1118** (e.g., a speaker), and a network interface device **1120**.

The drive unit **1116** includes a machine-readable medium **1122** on which is stored one or more sets of instructions **1124**

and data structures embodying or utilized by any one or more of the methodologies or functions described herein. The instructions **1124** may also reside, completely or at least partially, within the main memory **1104**, the static memory **1106**, and/or the processor **1102** during execution thereof by the computer processing system **1100**, with the main memory **1104**, the static memory **1106**, and the processor **1102** also constituting tangible machine-readable media **1122**.

The instructions **1124** may further be transmitted or received over a network **1126** via the network interface device **1120** utilizing any one of a number of well-known transfer protocols (e.g., Hypertext Transfer Protocol).

While the machine-readable medium **1122** is shown in an example embodiment to be a single medium, the term "machine-readable medium" should be taken to include a single medium or multiple media (e.g., a centralized or distributed database, and/or associated caches and servers) that store the one or more sets of instructions **1124**. The term "machine-readable medium" shall also be taken to include any medium that is capable of storing, encoding, or carrying a set of instructions **1124** for execution by the computer and that cause the computer to perform any one or more of the methodologies of the present application, or that is capable of storing, encoding, or carrying data structures utilized by or associated with such a set of instructions **1124**. The term "machine-readable medium" shall accordingly be taken to include, but not be limited to, solid-state memories, optical and magnetic media, and other non-transitory media.

While the example embodiments discussed herein are described with reference to various implementations and exploitations, these example embodiments are illustrative, and the scope of the disclosure is not so limited. In general, techniques for maintaining consistency between data structures may be implemented with facilities consistent with any hardware system or hardware systems defined herein. Many variations, modifications, additions, and improvements are possible.

Plural instances may be provided for components, operations, or structures described herein as a single instance. Finally, boundaries between various components, operations, and data stores are somewhat arbitrary, and particular operations are illustrated in the context of specific illustrative configurations. Other allocations of functionality are possible and may fall within a scope of various embodiments of the present disclosure. In general, structures and functionality presented as separate components in the exemplary configurations may be implemented as a combined structure or component. Similarly, structures and functionality presented as a single component may be implemented as separate components. These and other variations, modifications, additions, and improvements fall within a scope of embodiments of the present disclosure as represented by the appended claims.

What is claimed is:

1. A system comprising:

one or more hardware processors; and

a memory storing instructions that, when executed by at least one of the one or more hardware processors, cause the system to perform operations comprising:

retrieving, from a data store, a data set organized according to a first dimension;

calculating an influence value indicating an influence, on the data set, of a dimension value of the first dimension, the calculating of the influence value based on one or more factors, the one or more factors determined by employing at least one classification tree model, the one or more factors including an effect of the dimension value on a measure of the data set;

determining at least one of an influence rating and an influence ranking of the dimension value of the first dimension based on the calculated influence value, the at least one of the influence rating and the influence ranking providing a ranking or a rating of the dimension value relative to one or more other values of the data set;

causing, via a display device, presentation of the at least one of the influence rating and the influence ranking of the dimension value of the first dimension relative to the one or more other values of the retrieved data set in conjunction with a presentation of at least a portion of the retrieved data set; and

allowing modification of the dimension value to visualize, an effect of the modification on the one or more other values of the retrieved data set based on the influence dimension value.

2. The system of claim **1**, the calculating of the influence value comprising:

multiplying, for each of the one or more factors, the factor by a corresponding coefficient to yield a corresponding influence term; and

summing the corresponding influence terms.

3. The system of claim **2**, the calculating of the influence value further comprising: dividing the summed corresponding influence terms to produce the influence value.

4. The system of claim **1**, the operations further comprising:

generating, for the dimension value of the first dimension, the at least one classification tree model; and

determining, based on a weight associated with each leaf node of the at least one classification tree model, each of the one or more factors.

5. The system of claim **4**, wherein a target variable of the at least one classification tree model comprises a classification of a group of measures of the data set, the group of measures including the measure of the data set.

6. The system of claim **4**, wherein a root node of the at least one classification tree model comprises the first dimension.

7. The system of claim **4**, wherein the data set is organized according to a plurality of dimensions comprising the first dimension and an input variable of the at least one classification tree comprises a second dimension of the plurality of dimensions.

8. The system of claim **1**, the operations further comprising: employing a regression tree model to determine an additional factor of the influence value.

9. The system of claim **1**, the calculating of the influence value comprising: determining a number of times at least one conditional visual format is applied to the dimension value of the first dimension.

10. The system of claim **1**, the calculating of the influence value comprising: determining a number of presentation filters being based on the dimension value of the first dimension, the influence value being based on the number of presentation filters.

11. The system of claim **1**, the calculating of the influence value comprising: determining a number of times the dimension value of the first dimension is employed in one or more data set visualizations to be presented to a user, the influence value being based on the number of times the dimension value of the first dimension is employed in the one or more data set visualizations.

12. The system of claim 1, the calculating of the influence value comprising: determining a number of times the dimension value of the first dimension is employed to merge a plurality of data tables of the data set, the influence value being based on the number of times the dimension value of the first dimension is employed to merge the plurality of data tables of the data set.

13. The system of claim 1, the calculating of the influence value comprising: determining a number of times the dimension value of the first dimension is employed in one or more geographic dimension hierarchies of the data set, the influence value being based on the number of times the dimension value of the first dimension is employed in the one or more geographic dimension hierarchies of the data set.

14. The system of claim 1, the calculating of the influence value comprising: determining a number of times the dimension value of the first dimension is employed in one or more user-defined dimension hierarchies of the data set, the influence value being based on the number of times the dimension value of the first dimension is employed in the one or more user-defined dimension hierarchies of the data set.

15. The system of claim 1, the operations further comprising:

receiving a user selection of one of the dimension value of the first dimension; and

causing, via the display device, presentation of an indication of at least one factor of a plurality of numerical factors upon which the influence rating of the selected one of the dimension value of the first dimension is based.

16. The system of claim 1, the first dimension comprising a geographic dimension.

17. The system of claim 1, the system further comprising: a communication network interface configured to communicate via a communication network with a client device, the client device comprising the display device.

18. The system of claim 1, the calculating of the influence value comprising: determining a number of times the dimension value of the first dimension is employed in one or more user interface pages to be presented to a user, the influence value being based on the number of times the dimension value of the first dimension is employed in the one or more user interface pages.

19. A method comprising:

retrieving from a data store, a data set organized according to a first dimension;

calculating, using at least one hardware processor of a machine, an influence value indicating an influence of a dimension value of the first dimension, the calculating of the influence value based on one or more factors, the one or more factors determined by employing at least one classification tree model, the one or more factors including an effect of the dimension value on a measure of the data set;

determining at least one of an influence rating and an influence ranking of the dimension value of the first dimension based on the calculated influence value, the at least one of the influence rating and the influence ranking providing a ranking or a rating of the dimension value relative to one or more other values of the data set;

causing, via a display device, presentation of the at least one of the influence rating and the influence ranking of the dimension value of the first dimension relative to the one or more other values of the retrieved data set in conjunction with a presentation of at least a portion of the retrieved data set; and

allowing modification of the dimension value to visualize an effect of the modification on the one or more other values of the retrieved data set based on the influence dimension value.

20. A non-transitory computer-readable storage medium storing instructions that, when executed by one or more processors of a machine, cause the machine to perform operations comprising:

retrieving, from a data store, a data set organized according to a first dimension;

calculating an influence value indicating an influence, on the data set, of a dimension value of the first dimension, the calculating of the influence value based on one or more factors, the one or more factors determined by employing at least one classification tree model, the one or more factors including an effect of the dimension value on a measure of the data set;

determining at least one of an influence rating and an influence ranking of the dimension value of the first dimension based on the calculated influence value, the at least one of the influence rating and the influence ranking providing a ranking or a rating of the dimension value relative to one or more other values of the data set; and

causing, via a display device, presentation of the at least one of the influence rating and the influence ranking of the dimension value of the first dimension relative to the one or more other values of the retrieved data set in conjunction with a presentation of at least a portion of the retrieved data set; and

allowing modification of the dimension value to visualize an effect of the modification on the one or more other values of the retrieved data set based on the influence dimension value.

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